

Megatile Scanner Upgrade

Thomas Beardsley

Mentor: Jim Freeman



Abstract

Megatiles are large panels of scintillating material used in many particle detector projects, such as CMS HCAL. The megatile scanner is a two-axis machine that transports a radiation source to specified locations along a megatile and measures the current signal at each location. This tests each megatile for consistency and quality. The scanner had been decommissioned, but now has upgraded hardware and a new controls system. After installing all new components and establishing communications to all new devices to the control computer, a LabVIEW program was created to perform a scanning sequence to test megatiles.

Background

Scintillators are one of the most common materials used in devices for particle detection today. A scintillator is a material that emits light as ionizing radiation passes through it. The scintillator's light output is directly related to the energy of the incident radiation. This allows the scintillator to act as a radiation energy spectrometer. A scintillation detector normally consists of scintillation material, a photomultiplier tube (PMT), and a current sensor. The radiation excites the scintillator, then the light is converted through the PMT to an electric current signal, which can be analyzed to gather energy and timing data (Figure 1).

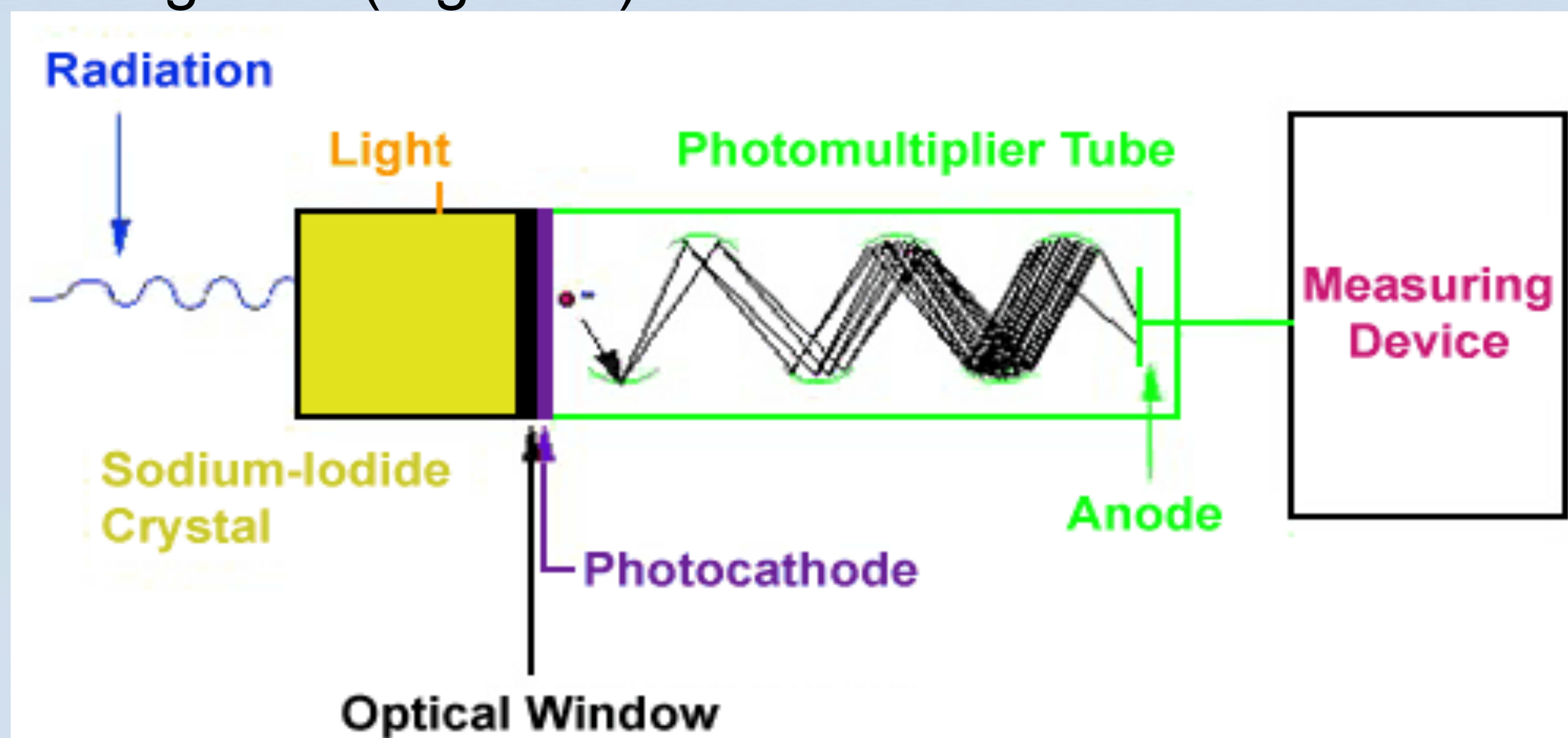


Figure 1. Basic setup of a scintillation detector.

The scintillation megatile scanner utilizes this detector setup to analyze large panels of scintillating material (megatiles) examining different properties of the megatiles, including the magnitude of the light output, as well as the uniformity of each megatile. The megatiles must be tested in this manner in order to ensure they were properly fabricated, and are ready to be installed. Currently, megatiles are utilized in the CMS HCAL design, used to measure the timing and energy of hadronic showers. The megatile scanner was used to test megatiles for this and other projects more than a decade ago. The scanner was severely outdated and not functioning in its current state. Major hardware and software changes were implemented in order to upgrade the scanner.

Initial Assessment

The first step in the upgrade process was to assess the current condition of the scanner and create a basis for documentation of the upgrade process. The scanner is a two-axis machine using two stepper motors and belt drive to transport a radiation source to

specific locations along a megatile with precision. The scanner gathers current signal data at each location. Two motion controllers are used to control the motors, one per axis, and a system of limit and homing switches are used to control overall motion (Figure 2).

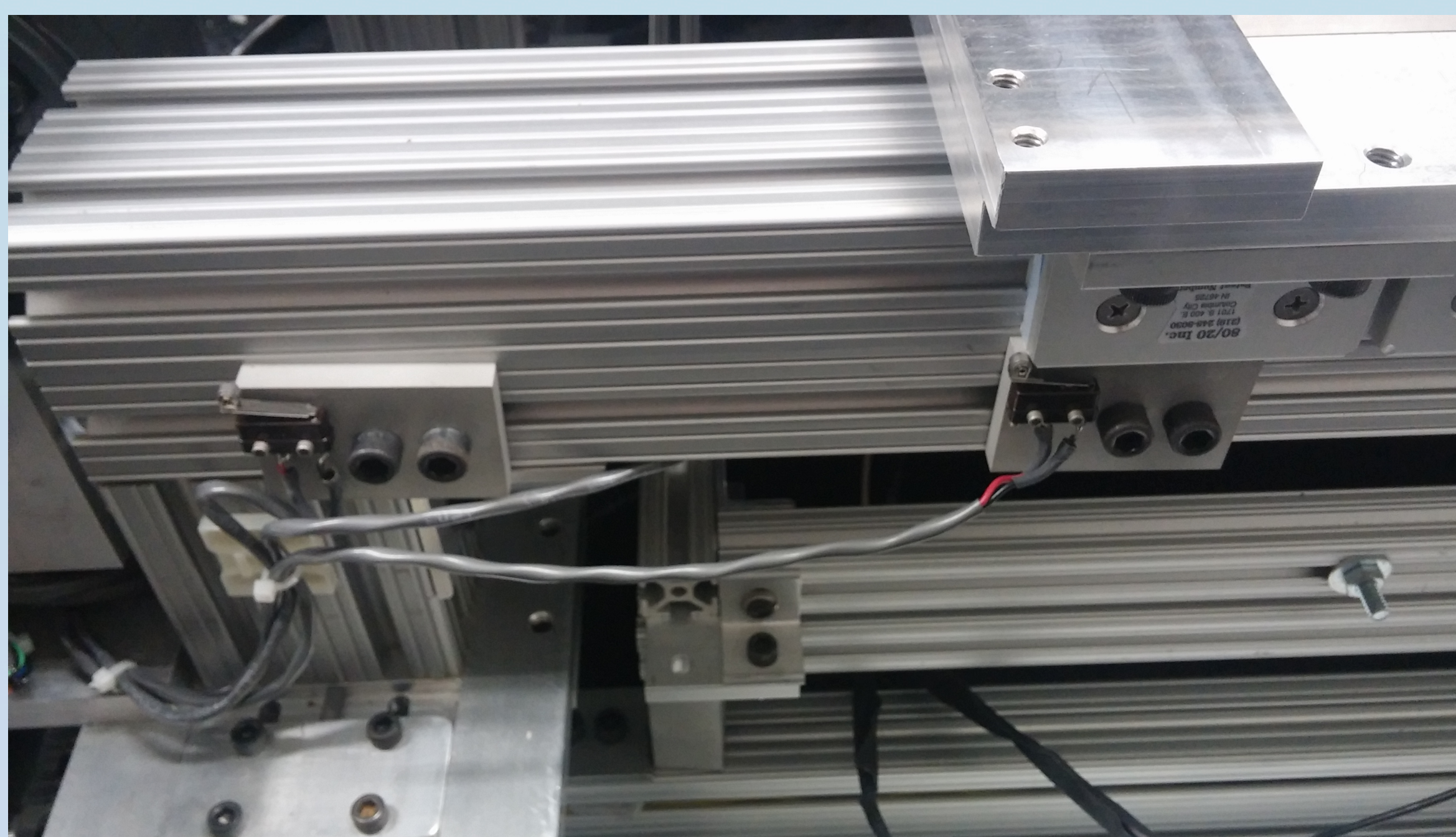


Figure 2. The (-) limit switch and homing switch for the X-axis of the scanner.

An initial wiring diagram was created in AutoCAD Electrical to act as a basis for further upgrades, providing a better understanding of how the scanner operated. Upon inspection, it was clear there were missing or outdated components that needed to be replaced or created, including new motion controllers, a new DAQ device, and new control software.

Hardware and Setup

The new controllers are MForce PowerDrives from Schneider Electric (Figure 3). Unlike the old setup, these new motion controllers allow for the motion of the system to be controlled entirely through the controllers, including driving the motor, as well as setting up limit and homing switches. The controllers utilize an I/O bank so that an input, such as a limit switch, can be wired to the I/O and programmed to whatever settings the user defines. This feature allows for a much simpler wiring setup, with all motion components being wired to the controllers, and only communication and power are wired out. A control computer operates the motion of the scanner via RS-485 serial communication with each motion controller.

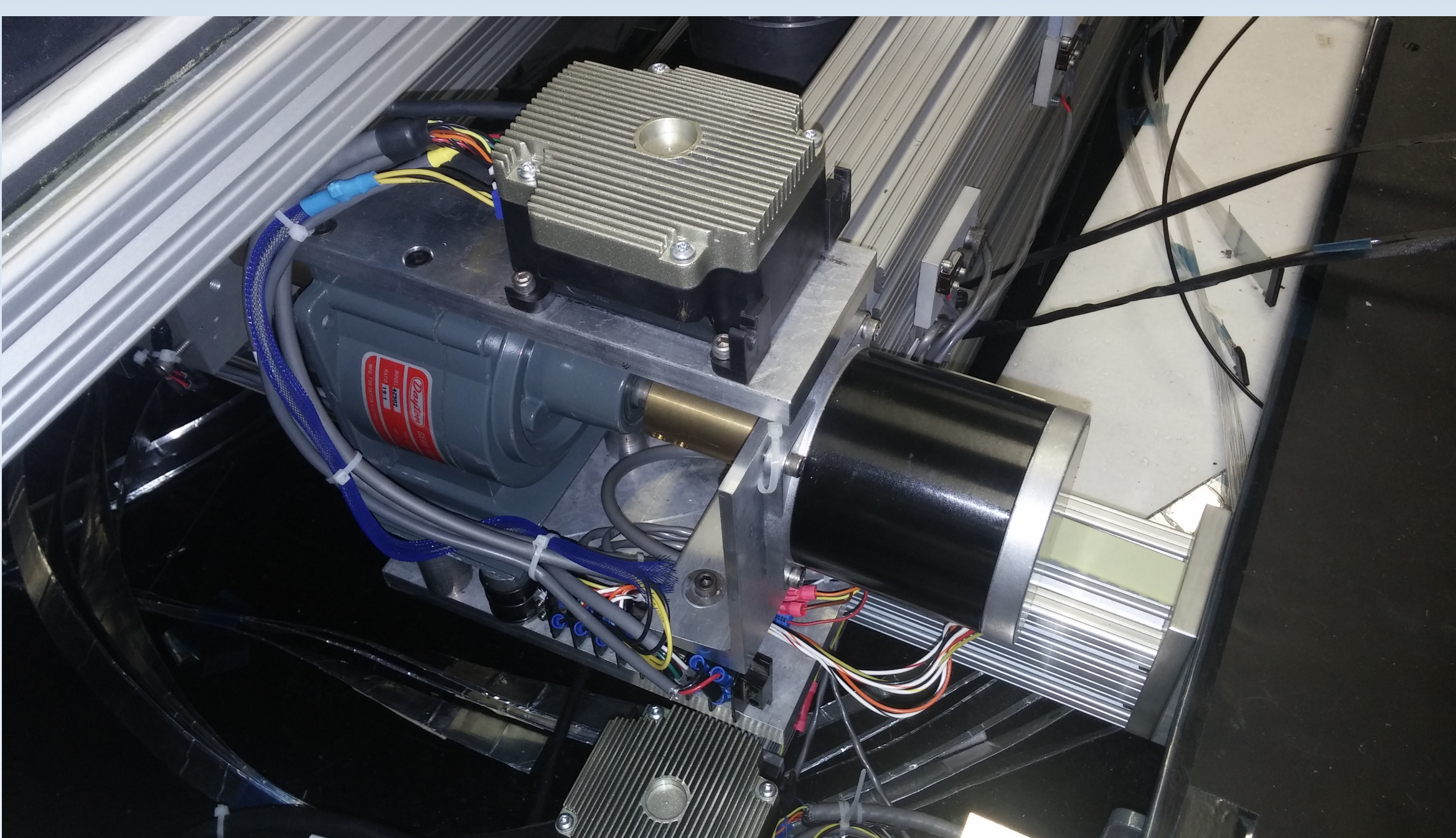


Figure 3. Setup of the MForce PowerDrive Motion Controller, Vexta PH296-E4.2 Stepper Motor, and Dayton 19:1 Gear Reducer that controls the X-axis of the scanner.

The new DAQ device is a Keithley 6487 Picoammeter/Voltage Source, and it is operated by the control computer via RS-232 serial communication. The device is primarily used to take current signal readings at each position after a move during a scan sequence.

Scanning Program

Before creating a scan program, each controller, each limit switch, and the DAQ device were all tested using a serial software terminal to send direct commands to the devices to ensure the correct responses. A program was then written in LabVIEW to perform a scan of a megatile. The devices are controlled with textual commands (MCode for the controllers or SCPI for the DAQ) sent using VISA Serial reads and writes within the LabVIEW program. Along with sending the these commands, LabVIEW is used to control timing and the process of events throughout the scan, as well as allow for user input. The following diagram outlines the program structure (Figure 4).

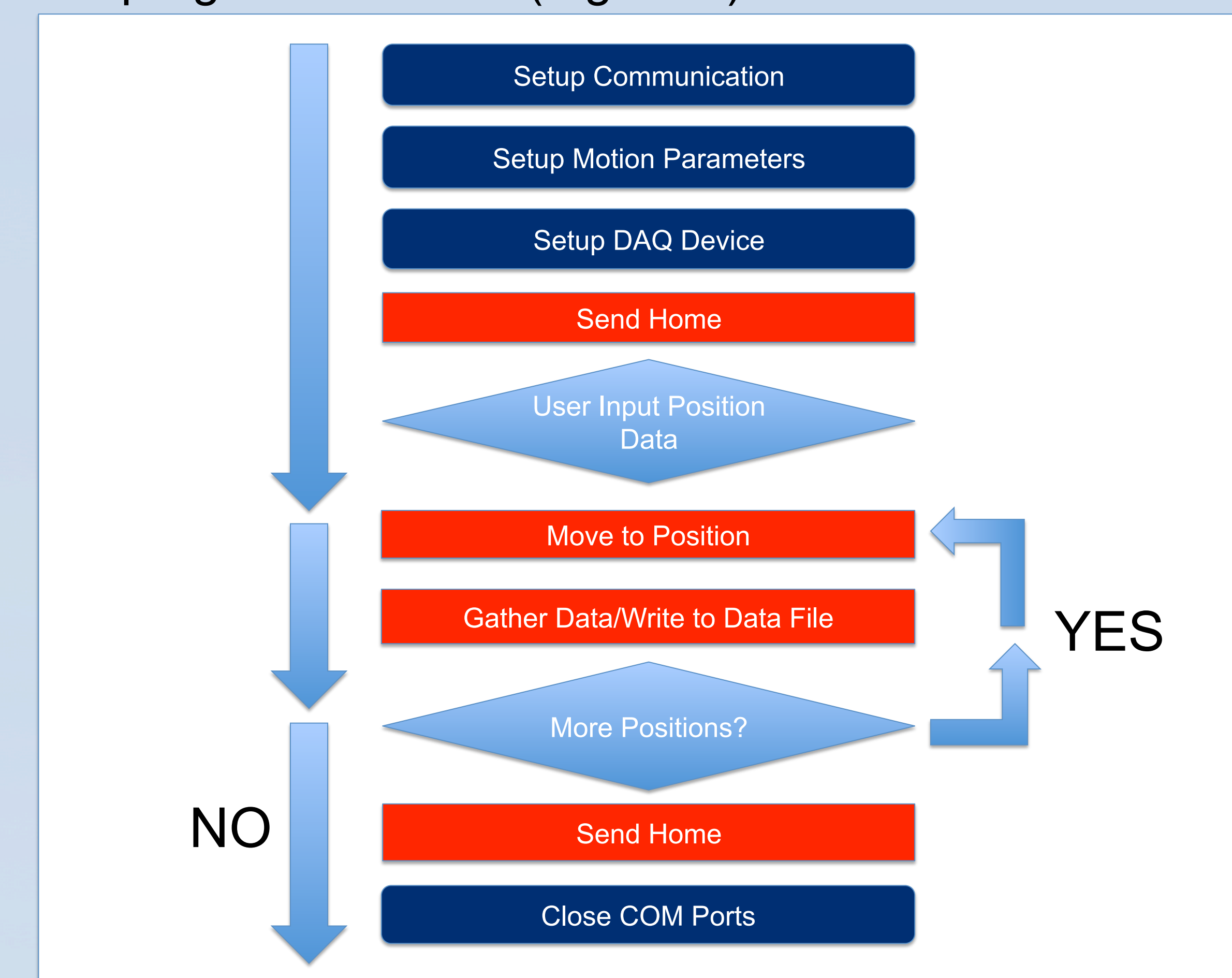


Figure 4. Flow diagram of the operational structure of the LabVIEW scan program.

Results/Conclusions

As of completion of this presentation, the scanning program is fully functional, including operation of all motion and the DAQ. The next phase of the upgrade process is installation of a PMT and optical cables to transport the light emitted by the megatiles so that testing of the scanner with a radiation source can begin. Once the scanner passes those tests, it will be fully operational and ready to be used. Further documentation of this upgrade includes a wiring diagram of the new electrical setup, a manual outlining the scanner's operations, as well as a step-by-step guide of the upgrade process. This upgrade allows for the scanner in its entirety to be replicated at CERN or elsewhere in the future.

References/Acknowledgments

Leo, William R. Techniques for Nuclear and Particle Physics Experiments. Berlin: Springer-Verlag, 1987. Print.

CMS-HCAL Collaboration. "Design, performance, and calibration of CMS hadron-barrel calorimeter wedges." *European Physical Journal C*. 55 (2008): 159-71. Print.

"Introduction to Radiation Detectors." Equipco. Equipco Rentals, n.d. Web. 27 July 2015. [Figure 1.]

Special thanks to Jerry Zimmerman, Bill Hefler and All Control for their technical support and guidance. All work was performed under the Community College Internship (CCI) Program.